

The University of Chicago

AN EXPERIMENTAL STUDY OF THE IN-
FLUENCE OF PUNISHMENT FOR
ERRORS DURING LEARNING
UPON RETENTION

A DISSERTATION SUBMITTED TO THE
FACULTY OF THE DIVISION OF THE BIO-
LOGICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

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By
CHUNG-FANG NI

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INTRODUCTION

Object

The use of punishment for errors in maze-learning, as reported by previous investigators, increases the efficiency in learning. This beneficial influence is manifested by a decrease in the number of errors, in the number of trials, and in the total amount of time required to complete the habit-formation. Since most of our learning is used for future adaptation, we are interested in the problem of retention as well as that of fixation. Here we desire to know the influence of punishment for errors during learning upon retention. This problem has already been attacked casually by previous investigators, but none of them has regarded it as his chief interest or has studied it in a systematic way. In the present experiment, the following problems have been proposed with a hope of throwing some light upon the intelligent use of this important incentive.

(1) Does the use of punishment for errors really have any influence upon the efficiency of learning? If there is any influence, is it beneficial or detrimental? As the efficiency of learning is represented by different criteria such as errors, trials, time and retracings, what influence has the use of punishment for errors upon each of them?

(2) When the degree of retention is measured by the efficiency of relearning, does the use of punishment for errors during learn-

¹ To Professor K. S. Lashley the writer wishes to express his indebtedness for suggestions and help given in the course of the experimentation.

ing have any influence upon retention as measured by these criteria? If there is any influence, is it beneficial or detrimental to retention? As the efficiency of relearning is represented by different criteria such as errors, trials, time and retracings, what influence has the use of punishment for errors during learning upon each of them?

The main object of this experiment, to state it briefly, is to determine whether the use of punishment for errors during learning has a beneficial, zero, or detrimental influence upon retention as measured by various criteria of the efficiency of relearning, and to express that influence in quantitative terms.

Historical review of the problem

Only very few investigations have been made concerning the influence of punishment upon efficiency of learning, or, especially, upon retention. A brief survey of them will give a background for the present experiment.

Yerkes (1907), the earliest investigator in this field, was of the opinion that the method of punishment is more satisfactory than the method of reward, because it can be controlled to a great extent. He also made the suggestion that punishment is a more efficient motive in animal behavior than the desire for food. But at the same time, Hamilton (1907) found that shock did not work at all with a dog. Yerkes (1908) also studied the relation of the strength of stimulus (electric shock for errors) to the rate of learning, finding it to be direct up to a certain optimal intensity. Furthermore, he concluded that the relation of the strength of electrical stimulus to rapidity of habit-formation depends on the difficulty of the habit, or upon the conditions of discrimination.

The same result was obtained by Cole (1911) with chicks. Reward, as reported by Hoge and Stocking (1912), was less effective than punishment in influencing the rate of learning. Dodson (1918) concluded from his experimental investigation that in the case of a simple discrimination problem the electric shock was more favorable to the learning process in the white rat than was hunger. He also found that subjects trained with electric stimulus retained better than subjects trained with hunger. Accord-

ing to Wylie (1919), the electric shock is the most effective stimulus, both from the point of view of rapidity of learning and from the point of view of smoothness of the learning curve, there being practically no lapse and no plateaus.

In a multiple-choice experiment, Kuo (1922) showed that the electric-shock compartment was the first one to be eliminated. A comparison was made by Moss (1924) between the reward and punishment incentive values for maze-learnings. When punishment was used as the incentive, the floor of all parts of the maze except that of the reward box was covered with crushed ice. Both sex and food seemed superior as incentives to this particular punishment method. The measurement of the permanency of the learning after thirty days showed that the punishment method was much inferior to both the sex and food. In a human multiple-choice reaction experiment in which electric shock was administered for errors, Rexroad (1926) got somewhat ambiguous results. The effect of the punishment, as observed by him, was to make the subjects more cautious and slower in action. Warden and Aylesworth (1927) studied the same problem as Hoge and Stocking, and confirmed their results. The effects of punishment on the learning of a human stylus maze were first systematically attacked by Bunch (1928). He found that punishment for errors facilitates learning. By studying the effect of different types of instruction upon quickness of stopping an arm movement in response to a red light, Vaughn (1928) concluded that electric shock as punishment for slowness in stopping is the most effective form of instruction. Valentine (1930) made an investigation concerning the effects of introduction of punishment into different stages of maze-learning, showing that punishment for errors results in a larger decrease in errors compared to learning without punishment. After a retention period of ninety days, the punishment for errors during learning had a beneficial influence upon recall but a zero influence upon relearning. By varying the intensity of punishment in learning a simple maze, Vaughn and Diserens (1930) found fewest trials, fewest errors, and least time with slight punishment.

A comprehensive survey of previous studies finally led Diserens

and Vaughn (1931) to conclude that the most effective intensity of electric shock has more incentive value in learning than has the most effective degree of hunger. In serial learning, McTeer (1931) noticed that the electric shock made the punishment groups more cautious. Caution on the part of the learners resulted in their learning the combinations used with fewer trials and fewer errors than the non-punished learners though they required the same amount of time. The influence of punishment during learning upon retroactive inhibition was studied by Bunch and McTeer (1932). They administered punishment for errors during mastery of a stylus maze used by Bunch, and confirmed his results. The punishment for errors during learning also resulted in greater retention of the maze solution for an interval of six weeks, when retention was measured by the relearning method; though, when measured by recall scores, retention was more efficient for a maze learned without punishment. Moreover, the amount of retroactive inhibition resulting from the acquisition of a second maze was reduced approximately one-half, except in terms of trials, when original learning occurred under punishment, or when punishment was administered for errors during the learning of the interpolated maze problem. In an experiment recently reported by Dodson (1932), three groups of human subjects, punished group, reward group, and non-reward group, were trained on a Yerkes multiple-choice apparatus and a stylus maze. The results show that punishment led to the quickest learning. Dorcus and Gray (1932), in their study in the effectiveness of food and electric shock in learning and retention by rats when applied at critical points in the maze, reported that in both learning and relearning, the shock group made fewer errors and retained the maze-pattern better than did the food group. But if the recall scores in terms of the number of errors made by each group on the first trial in relearning were used to measure the degree of retention, there was no difference between the food and the shock groups. In order to determine the relative effectiveness of reward and punishment, Thorndike (1932) required chicks to discriminate between three closed doors and three open doors. Response to one of the open doors was always followed by freedom and

food. Response to the second door was followed by a thirty-seconds confinement. Response to the third door was met by resistance. His results are in favor of the rewarding method.

From this brief review, several points may be noticed. First, the increase of the number of studies in this field during recent years serves to show our gradual appreciation of punishment as an important incentive. Second, the electric shock has been widely used as punishment. Third, previous studies, on the whole, seem to show that the electric shock as punishment facilitates learning. Fourth, the effect of shock is greatly influenced by other conditions. The efficiency of learning seems to vary with the strength of shock. Its optimal strength also differs for the problem. Fifth, not all types of punishment have the same influence upon learning. This phenomenon has been demonstrated by Kuo (1922), Moss (1924), and Thorndike (1932). A little increase in the distance of a path or a very short interval of confinement can hardly be called punishment. Crushed ice in the maze may be a distraction rather than a punishment. Sixth, very few investigations have touched upon our problem. They are Dodson's (1917), Moss's (1924), Valentine's (1930), Bunch and McTeer's (1932), and Dorcus and Gray's (1932). Seventh, each of these investigators is interested in something else rather than in our problem. Some are chiefly interested in the relation of punishment to reward (Dodson, Moss, Dorcus and Gray); some, to retroactive inhibition (Bunch and McTeer), and still others, to the different stages of learning (Valentine). Eighth, the results obtained by these investigators are not in agreement. The positive result obtained by Dodson is contradictory to Moss's negative result. When retention is measured by recall scores, Valentine got a positive result; Dorcus and Gray, a zero result, and Bunch and McTeer, a negative result. But when retention is measured by relearning scores, Valentine got a zero result which is different from a positive result obtained by the other investigators (Bunch and McTeer, Dorcus and Gray). In the present experiment, our chief interest is the relation of punishment to retention. In other words, we want to know whether the application of electric shock for errors during

learning has a beneficial, zero, or detrimental effect upon retention as measured by relearning scores.

EXPERIMENTAL PROCEDURES

Subject

One hundred and fifty-one albino rats were used in this experiment. Sixteen of them were discarded because of their failure in the initial trial in training, and six, because of sickness and death during the course of experimentation. Only one hundred and twenty-nine rats were finally available. They were almost equally divided into four groups similar with respect to number, age, sex and weight.

In the program followed by each group, group (1) N-N and group (2) N-P were control groups, Group (3) P-P and group (4) P-N, experimental. The control groups formed the maze habit without punishment for errors during learning, while with the experimental groups punishment was used. After an interval of thirty days, all were tested for retention by the method of relearning. But here group (2) N-P and group (3) P-P relearned the maze with punishment for errors. In this experiment, group (1) N-N was compared with group (4) P-N, and group (2) N-P, with group (3) P-P. The reason for including all four is to minimize the effect produced by the change of stimulus situation in relearning. This sort of control is necessary, because if a group is trained with punishment for errors and retested without, the failure to receive a shock in the cul-de-sac may, as a new situation, stimulate further exploration and errors.

Materials

The pattern of Lashley's maze III (1929) was used in the present experiment. This is a maze which requires alternate right and left turns in the true path. To suit our purpose, some modifications have been made in its starting-box, its number of culs-de-sac, its dimensions, the structure of its floor and cover, and its food-box. In the maze pattern as shown in figure 1, *S* represents the starting-box. It is 19.5 cm. in length; 10 cm. in width, and 9.5 cm. in depth. A piece of heavy wire-mesh was used as its

cover. The broken lines represent the door which prevents the rat from returning to the starting-box. It is opened and closed by the experimenter. There are 12 culs-de-sac, each of which is connected with the apparatus used to produce electric shock. The maze is 72.5 cm. in length; 56.5 cm. in width, and 9.5 cm. in depth. Each cul-de-sac is 15.5 cm. in length and 7 cm. in width. The size of each opening or door is approximately the same. The floor of the maze is made of a number of small, round, metal rods. The rods, alternately wired to the poles of an induction coil, are

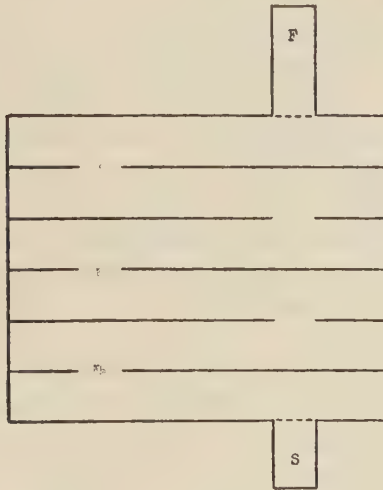


FIG. 1. THE MAZE PATTERN

used as a punishment grill. The floor of the true path presents the same appearance as the floor of the culs-de-sac. The rods can be easily washed with water. The cover of the maze is made of a piece of transparent glass. *F*, the food-box, is 37 cm. in length; 9.5 cm. in width, and 9.5 cm. in depth. It is removable, and can be washed easily. Its cover is made of a piece of heavy wire-mesh. In the end of the food-box, a removable food-cup is placed in an immovable one. The trap door is attached to a string with a weighted end so that it may be opened and closed at will.

The current used for punishment was obtained by stepping up

the commercial 110-volt current to 660 volts and reducing the amperage with a 100,000-ohm variable resistance.

To accustom the animals to handling before the beginning of training and to keep them adapted to the training situation during the interval between learning and retention tests, a straight runway, of a length equal to the total length of the true path of the maze, was used.

The food used for the rats consisted of milk-soaked bread, rabbit pellets, raw meat and green vegetables. Only the milk-soaked bread was used as the incentive.

As the food incentive was present in all four groups, the punished rats learned the maze not by punishment alone but by punishment plus food. The water maze has been used by McDougall (1927), and has given effective learning, with only "escape from punishment." As the use of the water maze is complicated by swimming and other factors, it seemed unsuited for our present investigation. It seems impossible to force rats through a maze by electric punishment alone. Therefore the combination of food and punishment was necessary.

Arrangement of conditions

After each rat had been labeled and classified, it was put through a standard routine of training. The whole schedule may be divided into five parts:

(1) *Conditions before the learning-period.* Each rat was allowed to run through the straight runway five times a day for three successive days before maze learning. At the end of each run, it was permitted to have one or two bites of food, and fed for five minutes in the food-box after its last run on each of the three days. This resulted in an average reduction in weight of 5 per cent.

(2) *Conditions during the learning-period.* After initial adaptation in the straight path, the animals were trained in the 12-culs-de-sac maze. The rats of group 3 and group 4 were punished for errors. The punishment for errors used throughout this experiment was electric shock of constant intensity. No measure-

ments of the intensity of the shock were secured,² but the animals reacted quite noticeably to it. To the human being it produced a tingling but not unpleasant sensation. The experiment was done in a room with electric light in daytime. Each rat of the four groups was trained to run the maze for 1 trial a day for the first two days. It was then given 5 trials per day thereafter until 5 successive errorless and retracingless trials were obtained. At the end of each trial, it was allowed to have one or two bites of food in the food-box. At the end of a day's training, it was allowed to eat for ten minutes in its home cage. Then it was kept in the home cage with water but without food. Each rat was weighed twice a week, and the weight was kept almost constant by regulating the length of time for feeding.

(3) *Conditions during the retention-period.* According to Tsai (1924), the rats on the average retained the maze habit more effectively than the human subjects during the first three or five weeks. In the present experiment, thirty days were arbitrarily chosen as the length of retention-period. During this interval, each rat was put through the straight runway 5 times a day, and then allowed to eat for ten minutes. The weight of the animals increased by an average of 10 per cent during the retention-period.

(4) *Conditions before the relearning-period.* In the last three days of the retention-period, the rat was allowed to eat only five minutes a day. Weight was reduced by about 5 per cent.

(5) *Conditions during the relearning-period.* In this period, each rat of the four groups was trained to run the maze with 5 trials per day until it made 5 consecutive trials without any error or retracing. Here only the rats of group 2 and group 3 were punished for errors. The control of punishment, light, food and weight in this period was of the same as that in the learning-period.

² No accurate method of controlling the severity of electric punishment has yet been devised (Muenzinger and Mize, 1933). Since we are not at present concerned with comparison of different degrees of punishment, the gross estimate of severity of punishment in terms of the animal's behavior is adequate.

Scoring

In this experiment, four criteria, time, retracings, trials, and errors, were used to measure the efficiency of both learning and relearning. As suggested by Tolman (1927), the number of errors is the most significant criterion since it shows the greatest consistency. Next to it is the number of trials. The other two criteria, time and retracings, may be simply used to help us for the further analysis of the problem. Here a somewhat detailed description is given to each of them.

(1) *Time*. The length of time required by the rat to reach the food-box after its entering into the maze from the starting-box was recorded. According to Tolman, time is an ambiguous measure of learning for two reasons: (a) It depends upon temperamental and physiological as well as upon learning factors. (b) It is unduly weighted by initial errors. In our experiments, it may serve as an indicator of cautiousness.

(2) *Retracings*. A retracing was counted when the rat turned and ran backward toward the starting-box. Another retracing was recorded when the rat passed a door and ran back from this section of the true pathway to another, and so on for the rest of the sections. This sort of treatment makes all retracings almost equal in distance. Here this criterion may possibly indicate some effect of punishment.

(3) *Trials*. A trial was counted as a complete trip from the starting-box to the food-box. If the rat had not reached the food-box within thirty minutes, it was put for a moment in the food-box, and allowed to have one or two bites of food. Then it was returned to its home-cage with water but without food. On the following day, the training was continued, and the time spent in the first day was added to the time score of the second, and counted as a single trial. The rat was treated in the same way as before if it failed again on the second day. Beyond three days, this retarded rat was discarded. Although the number of trials is a type of score which allows no internal method of testing for reliability (Tolman, 1927), it is regarded here as the criterion next in importance to the number of errors. In this experiment the

standard of complete learning or relearning was 5 consecutive errorless and retracingless trials.

(4) *Errors.* An error was recorded when the rat's two forefeet got into a cul-de-sac. The number of errors is probably the most reliable score for measuring learning and relearning (Lashley and Wiley, 1933).

Average time per trial and average errors per trial were computed, but the results do not seem capable of any significant interpretation. In the case of the punished animals the errors are concentrated in the initial trial, and proportionately a greater time was spent in the first trial than in the case of the non-punished groups. Consequently the computation of averages merely smooths out these differences, and the averages do not give a true picture of the conditions in the punished and non-punished groups.

Correction of data

In general, the groups showed consistent differences, but in some of the groups a few animals showed an abnormal deviation from the group mean. Such deviations are almost certainly due to individual peculiarities which are independent of the different methods of training employed. It is therefore justifiable to eliminate these extreme deviates as abnormal cases, if the same criterion of abnormality is applied to the members of all groups. After the means and standard deviations of all cases had been computed, all animals deviating more than three times the standard deviation from the group mean were eliminated and new means computed for the remainder. These latter constants seem the more valid measure of the influence of the method of training upon learning and retention. Both the original means (O) and the corrected means (C) are given in the tables.

EXPERIMENTAL RESULTS

Learning scores

The mean scores and their probable errors for the entire period of original learning of the maze are given in table 1. In

trials and errors there are significant differences between the scores of the groups with and without punishment, the punished animals requiring only 37 per cent as many trials and 60 per

TABLE 1

Original and corrected scores in learning

O, uncorrected scores; C, scores corrected by elimination of extreme deviates; M, mean; PE, probable error; N-N, no punishment in learning or retention tests; P-N, punishment in learning but not in retention tests; N-P, no punishment in learning but in retention tests; P-P, punishment in learning or retention tests.

GROUP	TYPE OF SCORES	NUMBER OF SUBJECTS	TIME		RETRACINGS		TRIALS		ERRORS	
			M	PE	M	PE	M	PE	M	PE
N-N	O	32	1939	±316	39.06	±3.43	27.66	±8.18	79.69	±5.79
	C	31	1963	±326	39.23	±3.54	27.80	±1.79	78.87	±6.64
P-N	O	33	2343	±250	41.70	±3.99	11.30	±1.03	42.76	±3.33
	C	29	2275	±280	38.86	±4.24	10.28	±0.91	36.75	±2.13
N-P	O	31	1299	±186	34.48	±3.43	25.58	±2.12	67.29	±5.10
	C	30	1071	±106	32.43	±3.25	24.47	±2.05	62.30	±4.00
P-P	O	33	1785	±160	37.85	±3.11	9.52	±0.88	49.18	±4.04
	C	32	1754	±163	36.41	±3.04	9.03	±0.85	45.69	±3.40

TABLE 2

Differences in the total number of trials and errors in learning

(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TRIALS				ERRORS			
		D	D in percentage	PE (diff.)	D/PE (diff.)	D	D in percentage	PE (diff.)	D/PE (diff.)
N-N vs. P-N	O	16.36	59	2.51	8.18	36.93	46	6.68	5.53
	C	17.52	63	2.01	8.72	42.12	53	6.97	6.04
N-P vs. P-P	O	16.06	63	2.29	7.01	18.11	27	6.51	2.78
	C	15.44	63	2.22	6.95	16.61	27	5.25	3.16

cent as many errors as the non-punished (table 2). By these criteria the effectiveness of punishment in facilitating learning is unmistakable.

Time and retracings give less reliable differences (table 3). As stated above these are probably not valid measures of learning, but indices of general activity, emotional disturbance and the like.

The significance of these criteria appears upon further analysis of the data. A study of the learning scores of the initial trial (tables 4 and 5) and the behavior of the animals give us additional facts.

Time appears to be a measure of initial emotional disturbance or "cautiousness." The punished animals spent more time in the first trial than the non-punished. After one or more shocks, most of the animals in the punished groups remained motionless in the

TABLE 3

Differences in the total amount of time and the total number of retracings in learning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TIME			RETRACINGS		
		D	PE (diff.)	D/PE (diff.)	D	PE (diff.)	D/PE (diff.)
N-N vs. P-N	O	-404	403	-1.00	-2.64	5.26	0.50
	C	-312	430	-0.72	0.37	5.23	0.07
N-P vs. P-P	O	-486	243	-2.00	-3.37	4.63	-0.73
	C	-683	194	-3.52	-3.98	4.45	-0.89

true path. More of the punished animals were also discarded because of failure to complete the first trial than of the non-punished.

Another measure like time is the number of retracings. In the initial trial, it was fewer for the non-punished animals. For the punished animals, frequent retracings took place in one or another segment of the true path, especially in the first. Like time, the retracings seem to be an index of the early emotional disturbance following punishment. The punished animals often ran back and forth in the true path between the cu s-de-sac before venturing into another segment of the maze. This tendency to increase retracings may be responsible for the larger number of errors made by the punished animals in the first trials of training.

The difference in the error scores of the initial trial between

punished and non-punished groups are inconsistent and unreliable, but the apparently greater concentration of errors in the early trials of the punished groups might be indirectly the result

TABLE 4
Original and corrected scores of the initial trial in learning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TIME		RETRACINGS		ERRORS	
		M	PE	M	PE	M	PE
N-N	O	599	± 123	13.19	± 1.47	31.06	± 2.98
	C	611	± 127	13.23	± 1.52	31.19	± 3.08
P-N	O	1584	± 189	27.24	± 3.29	30.76	± 2.40
	C	1554	± 209	27.00	± 3.52	28.14	± 2.01
N-P	O	492	± 75.44	12.90	± 1.53	26.23	± 2.27
	C	497	± 77.79	13.20	± 1.57	26.50	± 2.34
P-P	O	1305	± 140	26.42	± 2.66	37.12	± 3.01
	C	1301	± 144	26.31	± 2.74	35.28	± 2.83

TABLE 5
Differences in the scores of the initial trial in learning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TIME			RETRACINGS			ERRORS		
		D	PE (diff.)	D/PE (diff.)	D	PE (diff.)	D/PE (diff.)	D	PE (diff.)	D/PE (diff.)
N-N vs.	O	-985	226	-4.36	-14.05	3.60	-3.90	0.30	3.83	0.08
P-N	C	-943	245	-3.85	-13.77	3.83	-3.60	3.05	3.68	0.83
N-P vs.	O	-813	159	-5.11	-13.52	3.07	-4.40	10.89	3.77	-2.89
P-P	C	-804	164	-4.90	-13.11	3.16	-4.15	8.78	3.67	-2.39

of the retracings, as affording a greater opportunity for chance errors.

Other indications of emotional disturbance in the first trial were urination and active attacks upon the floor of the maze. The

direct evidence of emotional disturbance and the difference in time and retracings all disappeared in later trials.

In general, the use of punishment for errors does not influence all the criteria of learning equally. Trials and errors give significant differences. Time and retracings do not. The last two are not valid criteria of learning, as is shown by a comparison of early with later trials. The change in these criteria as training progresses together with the general behavior of the animals show that excess time and retracings are to be considered as indices of

TABLE 6
Original and corrected scores in relearning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	NUMBER OF SUB-JECTS	TIME		RETRACINGS		TRIALS		ERRORS	
			M	PE	M	PE	M	PE	M	PE
N-N	O	32	93.81	± 15.37	1.75	± 0.45	7.44	± 0.97	5.41	± 0.70
	C	31	86.39	± 13.80	1.39	± 0.39	6.58	± 0.82	4.90	± 0.64
P-N	O	33	71.30	± 23.97	1.15	± 0.36	3.15	± 0.85	1.42	± 0.51
	C	29	18.34	± 4.81	0.45	± 0.19	1.31	± 0.32	0.52	± 0.17
N-P	O	31	47.87	± 5.51	1.26	± 0.36	4.00	± 0.39	2.90	± 0.27
	C	30	47.77	± 5.69	1.30	± 0.36	3.93	± 0.40	2.70	± 0.24
P-P	O	33	12.94	± 3.11	0.39	± 0.13	0.85	± 0.19	0.39	± 0.11
	C	32	13.34	± 3.24	0.41	± 0.14	0.88	± 0.20	0.41	± 0.11

the original emotional disturbance produced by the punishment. Trials and errors are therefore the really significant indices of learning and show clearly the superiority of punishment.

Relearning scores

In table 6, the mean scores and their probable errors for the whole period of relearning of the maze are presented. Significant differences between the scores of the groups previously trained with and without punishment have been found in the total number of trials and errors in relearning (table 7). The animals which were punished during training required only 20 per cent as many trials and made 11 per cent as many errors in relearning as did

their controls, when no punishment was used during relearning (table 7). With punishment also during relearning the greater efficiency of punishment during initial learning appeared, the initially punished animals requiring only 22 per cent as many trials and making only 15 per cent as many errors as the non-punished (table 7).

Averaging the two groups in table 7, the use of punishment for errors in initial learning produces a saving of 79 per cent in trials and 87 per cent in errors.

TABLE 7
Differences in the total number of trials and errors in relearning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TRIALS				ERRORS			
		D	D in per-centage	PE (diff.)	D/PE (diff.)	D	D in per-centage	PE (diff.)	D/PE (diff.)
N-N vs. P-N	O	4.29	58	1.26	3.40	3.99	74	0.87	4.59
	C	5.27	80	0.88	5.99	4.38	89	0.66	6.64
N-P vs. P-P	O	3.15	79	0.44	7.16	2.51	87	0.28	8.96
	C	3.05	78	0.45	6.78	2.29	85	0.26	8.81

Another fact which may be noted from table 6 is that punishment during relearning also increases efficiency in relearning. Of the groups trained without punishment in initial learning, that receiving punishment during relearning made by far the better record.

Significant differences have also been found in the total time scores for relearning between the groups with and without punishment in initial learning. The P-N group is 68 per cent superior to the N-N, and the P-P group, 34 per cent superior to the N-P. Thus the effect of punishment in the first trials of initial learning in increasing time spent in the maze does not carry over into the initial trials of relearning, and the superiority of the punished animals in time spent is apparent (table 8). The animals, on the whole, seemed to be less excited by the shock in relearning,

no matter whether they had been punished in learning, or were for the first time punished.

In retracings, differences are positive, but not reliable (table 8). On the other hand, the animals with some punishment experience

TABLE 8

Differences in the total amount of time and the total number of retracings in relearning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TIME			RETRACINGS		
		D	PE (diff.)	D/PE (diff.)	D	PE (diff.)	D/PE (diff.)
N-N vs. P-N	O	26.51	28.50	0.93	0.60	0.57	1.05
	C	68.05	14.63	4.65	0.94	0.44	2.14
N-P vs. P-P	O	34.93	6.33	5.52	0.87	0.39	2.23
	C	34.43	6.55	5.26	0.89	0.39	2.28

TABLE 9

Original and corrected scores of the initial trial in relearning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TIME		RETRACINGS		ERRORS	
		M	PE	M	PE	M	PE
N-N	O	26.53	±7.04	0.56	±0.33	1.56	±0.42
	C	26.68	±7.26	0.58	±0.34	1.55	±0.43
P-N	O	19.45	±2.11	0.15	±0.05	0.06	±0.03
	C	19.31	±2.36	0.14	±0.06	0.03	±0.02
N-P	O	19.00	±3.61	0.68	±0.30	1.19	±0.22
	C	19.00	±3.73	0.70	±0.31	1.10	±0.21
P-P	O	13.88	±0.57	0.06	±0.03	0.09	±0.04
	C	14.00	±0.58	0.06	±0.03	0.09	±0.05

hesitated longer in the starting-box, still showing a certain degree of "cautiousness."

Apparently, when the maze is a familiar situation, punishment has little disturbing effect.

In the initial trial of relearning, significant differences have been found only in errors (tables 9 and 10). Differences in time and

retracings are not reliable, probably due to the change of effects of punishment in a familiar situation.

Generally speaking, we have found a beneficial influence of punishment for errors during learning upon all of the four criteria of relearning, i.e., errors, trials, time and retracings. With the exception of retracings, the differences are statistically reliable. In the initial trial in relearning, significant differences have also been found in errors but not in time and retracings. The latter, however, do show a change of the effects of punishment in a familiar situation. As trials and errors are valid indices of the efficiency of relearning, the advantage of punishment is obvious.

TABLE 10
Differences in the scores of the initial trial in relearning
(Abbreviations as in table 1)

GROUP	TYPE OF SCORES	TIME			RETRACINGS			ERRORS		
		D	PE (diff.)	D/PE (diff.)	D	PE (diff.)	D/PE (diff.)	D	PE (diff.)	D/PE (diff.)
N-N vs. P-N	O	7.08	7.35	0.96	0.41	0.33	1.24	1.50	0.42	3.57
	C	7.37	7.63	0.97	0.44	0.35	1.26	1.52	0.42	3.62
N-P vs. P-P	O	5.12	3.65	1.40	0.62	0.30	2.07	1.10	0.22	5.00
	C	5.00	3.77	1.33	0.64	0.32	2.00	1.10	0.20	5.50

THEORETICAL DISCUSSION

Our data have shown that under certain conditions the influence of punishment for errors during learning upon retention is beneficial. But why is this so? We do not know yet. An analysis of our standard of complete learning, however, reveals the fact that other factors which cannot be directly observed such as the degree of integration of the habit, the ease of performance, the kind of attitude attached to the habit and so forth are not taken at all into consideration. No distinction has been made between an animal with something more than the necessary requirement for complete learning and the one which barely reaches it. The

neglect of such factors in the standard of complete learning may account for the superiority of one animal over another in the efficiency of relearning, if other conditions for these two animals during the retention period are the same. In other words, the use of punishment for errors may affect not only the total number of trials and errors in learning but also something else which is probably relevant to retention. It is still possible that the punishment for errors has a more beneficial influence upon the latter than upon the former. A study of our problem suggests three possible explanations for the phenomenon of better retention in the animals trained with punishment.

A first possible explanation is that animals trained with punishment may form more deeply ingrained habits or "stronger engrams" than those without. This difference in original learning possibly leads to an increase in the efficiency in relearning. But how do we determine the degree of integration of a given habit formed with punishment for errors? One way is to measure the degree of negative transfer in the formation of an antagonistic habit. The animal trained with punishment may be expected to have more difficulty in forming the new habit if the old one is really better fixated.

Another possibility is concerned with the attachment of a general cautious attitude to the maze habit in the animal strained with punishment. The increase in the efficiency of relearning may be due to the inhibition of unnecessary exploration. The advantage of this factor could be well demonstrated after control of the first factor, that is, the better fixation of the maze pattern. Animals trained with and without punishment are to be required to learn a new maze of different pattern after they have completed the learning of the old one. If the factor of cautiousness really means something for the learning process, then the animals with some punishment experience should form the new maze-habit very much better.

Still another alternative is that in animals trained with punishment a cautious attitude may be attached to each specific cul-de-sac through the process of conditioning. This fear reaction may inhibit a tendency to re-exploration of specific culs-de-sac and so

give a spurious appearance of better retention. There is a possible test for this factor. In original learning, we may apply or distribute the punishment for errors to only one-half of the culs-de-sac of the same maze. Then a comparison is made in relearning between the number of errors occurring in the culs-de-sac with punishment and that in the culs-de-sac without punishment. This explanation would be verified if we should find fewer errors present in these culs-de-sac with punishment.

Each of these possibilities may be used to explain the phenomenon of better retention scores in the animals trained with punishment. There is no experimental evidence upon which we can accept a particular one and discard the others. Moreover, the true story may need for its explanation a combination of any two of them, all of them, or even none of them. Further researches are necessary to give us a definite answer to our question.

Briefly speaking, the effects of punishment may be brought about in more than one way. If retroactive inhibition, as suggested by McGeoch (1932), is the chief factor to account for forgetting, then one of the factors in the superior retentiveness of punished animals would be an increased resistance of the maze habit to this detrimental force. There are still other possible factors in the effects of punishment of which we know little as yet. The punished animals may be more affected by the increase of the standard of complete learning, e.g., from five consecutive errorless and retracingless trials to ten or more such perfect trials. They may be less susceptible to the detrimental influence of distractions, rough handling, delayed feeding, decrease of food incentive by feeding for a few minutes before maze-running, removal of vision, and the like. They may also have more negative or positive transfer as the case may be. As these characteristics are interrelated to each other, we cannot now expect to have a thorough understanding of one of them without taking the other into consideration. To discover that animals trained with punishment retain their habit better is easy, but when we come to deal with the cause-effect relationships of this phenomenon, many other factors are involved, and they can only be understood by experimental investigations. For this reason the writer finds it

better to use the present discussion to stimulate further researches in our problem than to attempt a theoretical explanation with an insufficient factual basis.

CONCLUSION

In the present experiment, four groups of rats were employed. The first two groups formed the maze habit without punishment for errors during learning, and with the second two groups punishment was used. After an interval of thirty days, all were tested for retention under controlled conditions by the method of relearning. The main results may be summarized as follows:

(1) The punishment for errors increased efficiency in learning. It decreased the total number of both trials and errors required to learn the maze. But on the other hand, it led to emotional disturbance in the initial stage of learning, and therefore, produced some uncertain and probably detrimental effects upon our two less valid measures, the total amount of time and the total number of retracings.

(2) The punishment for errors during learning increased efficiency in relearning. In the initial trial in relearning, it produced a significant decrease in errors but not in time and retracings. The decrease was also significant in the total number of trials, the total number of errors, and the total amount of time required to relearn the maze. Retravings alone show no reliable influence.

As more credits are given to trials and errors in our experiment, we may come to the conclusion that under conditions such as we have in our present investigation the *punishment for errors during learning has a beneficial influence not only upon habit-formation but also upon retention*. Further researches are needed to show whether the same results may be obtained with other forms of punishment, with different strengths of the shock, with other subjects, with different problems, or with many other conditions.

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